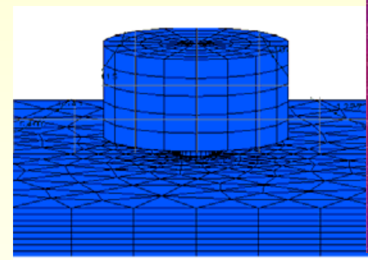
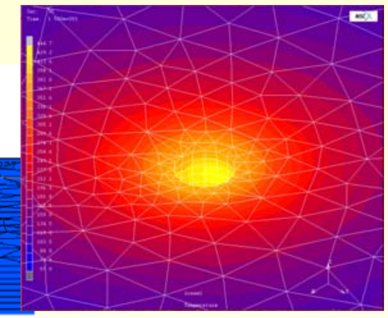
FEM Model and Experiments for Friction Stir Spot Welding of AA6061-T4





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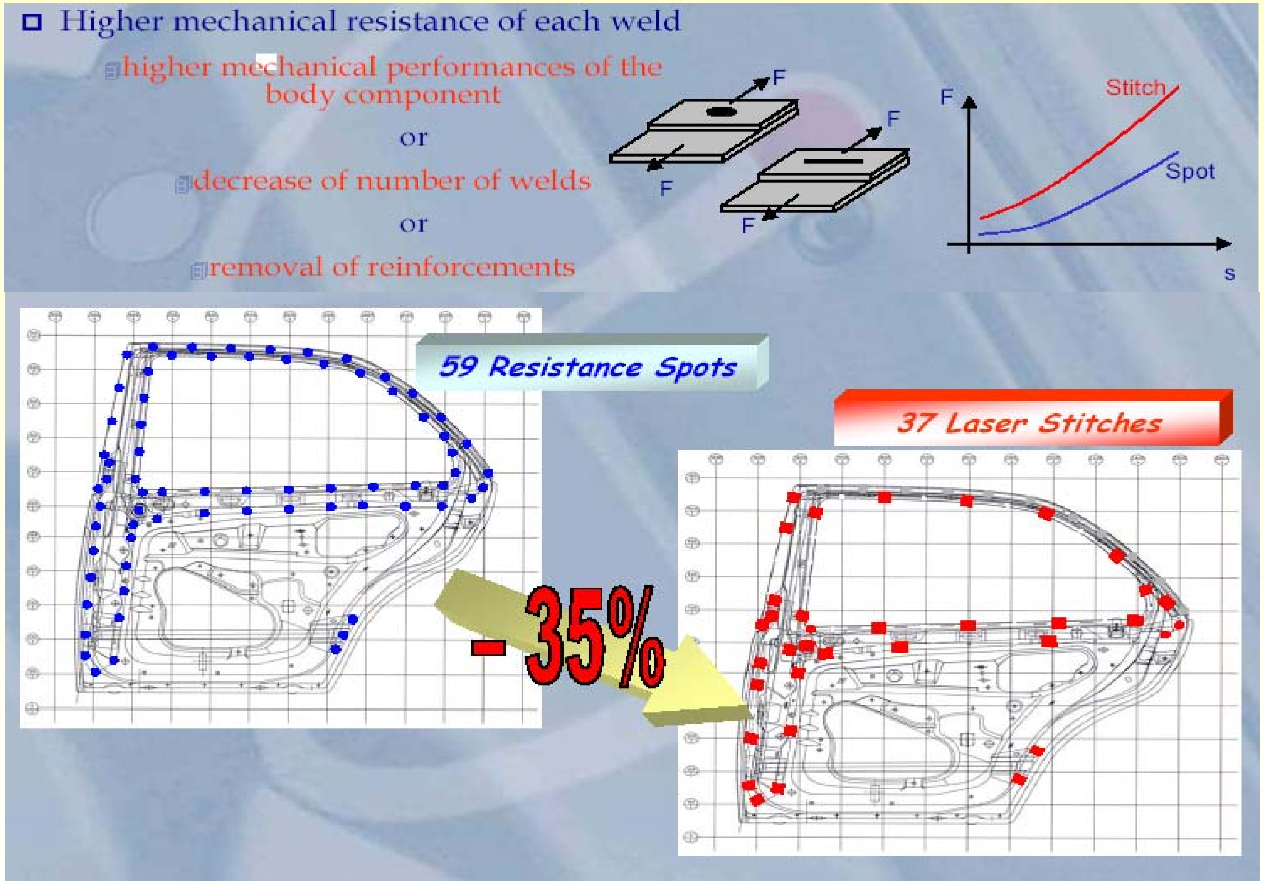
Outline

1. Introduction, problem definition
2. FEM model – conditions
3. FEM model – several results
4. Validating the model
5. Conclusion and outlook

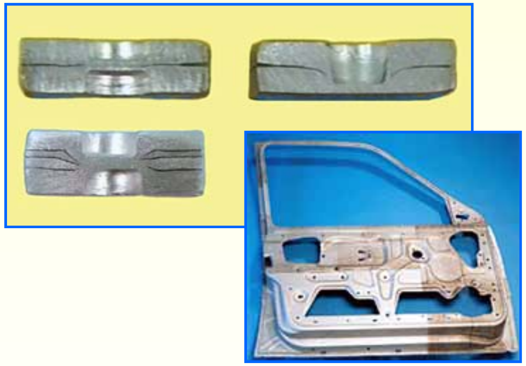
1. Introduction, problem definition

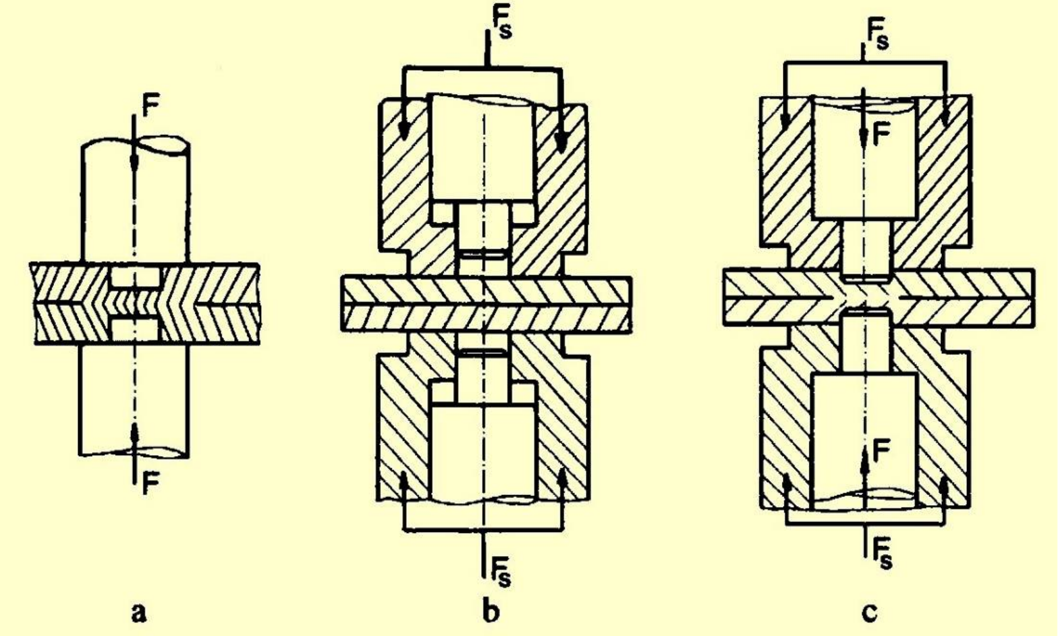
RESISTANCE SPOT WELDING



REMOTE LASER WELDING

1. Introduction, problem definition



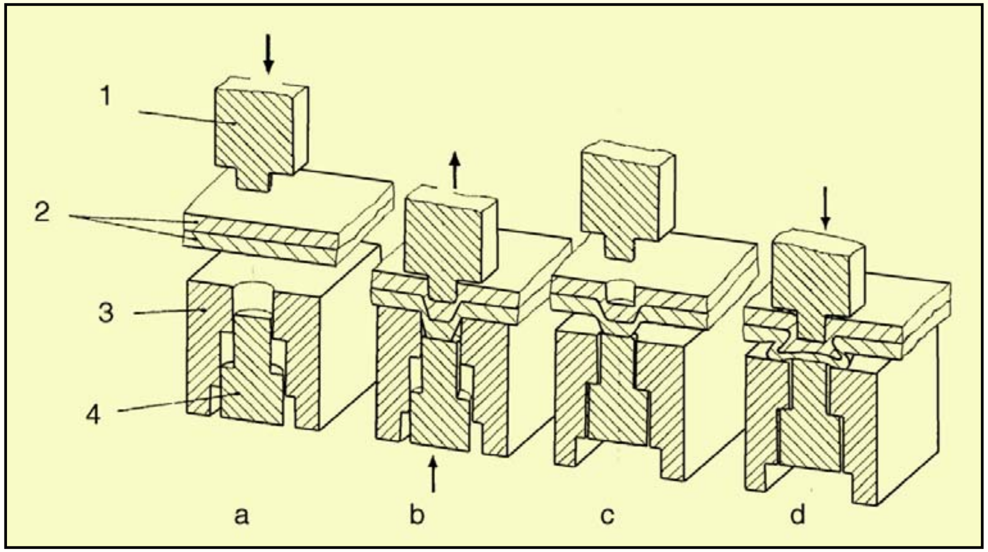


SPOT COLD WELDING

1. Introduction, problem definition

SPOT COLD WELDING

CLINCHING WITHOUT LOCAL INCISION



1. Introduction, problem definition

Overlap FSSW of multiple plates,
various thicknesses

APPROACH:

- FEM modelling of FSSW on plate
- Appropriate validation (experiment + literature)
- Defining effectiveness criteria

ENVISAGES:

- Optimizing the procedures
- Use of optimum code
- Opening wide and flexible prospects

1. Introduction, problem definition

Start up:

The plate:
- AA 6061-T4
- rectangular shape, 100 × 60 × 10 mm

Table 1: *Chemical composition of alloy AA6061*

AA6061 - Chemical composition (wt %)								
Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.66	0.25	0.31	0.08	0.99	0.16	0.01	0.02	bal.

1. Introduction, defining the problem

FSSW main parameters

- type of FSSW: simple
- tool rotational speed
- plunge rate & depth
- dwell time
- retreat time

2. FEM model – conditions

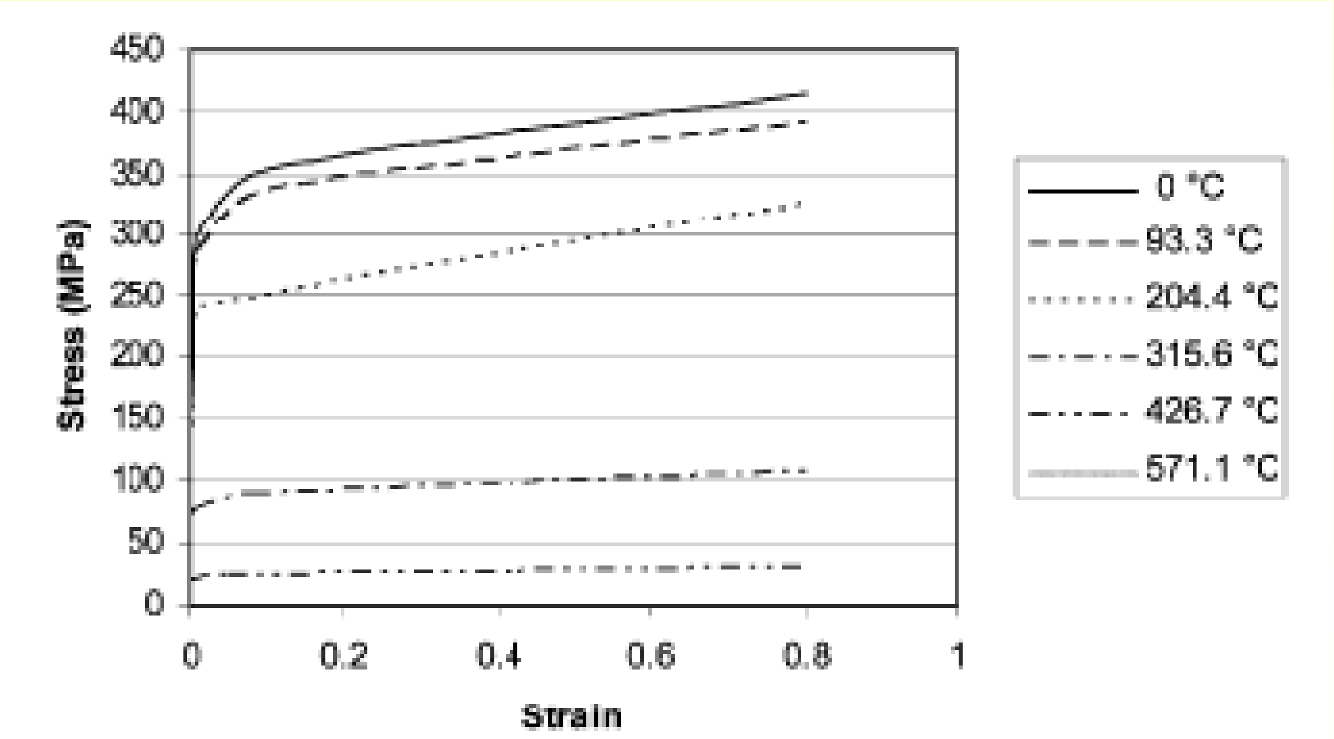
- Marc Mentat 3 code
- 3D
- thermo-mechanically coupled modelling
- temperature and multilinear strain hardening effects

Friction coefficient	0.4
Applied force	25 KN

Temperature-dependent thermo-physical properties for AA6061-T4 were adapted from literature

2. FEM model – conditions

Stress–strain curves of AA 6061-T4



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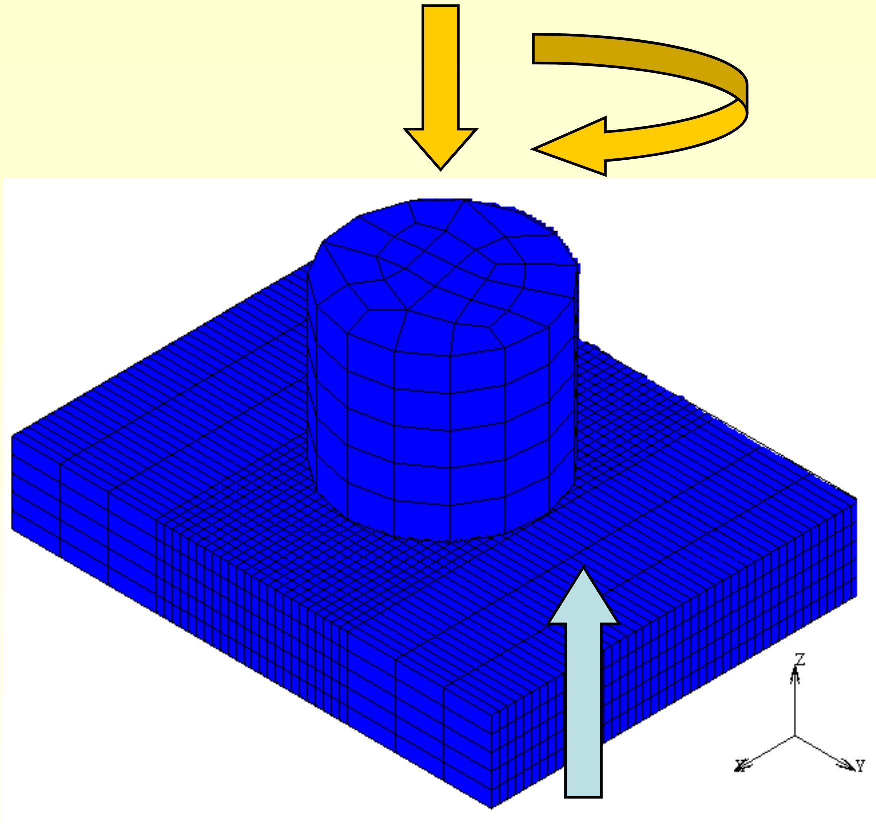
2. FEM model – conditions

FSP tool geometric characteristics and process parameters

Shoulder diameter [mm]	**15**
Pin diameter [mm]	**5**
Pin length [mm]	**4**
Rotation speed ω, [rpm]	**1120**
Friction pressure (up-setting force), [kN]	**25**
Plunge rate [mm/s]	**1.25**
Dwell time [s]	**4**

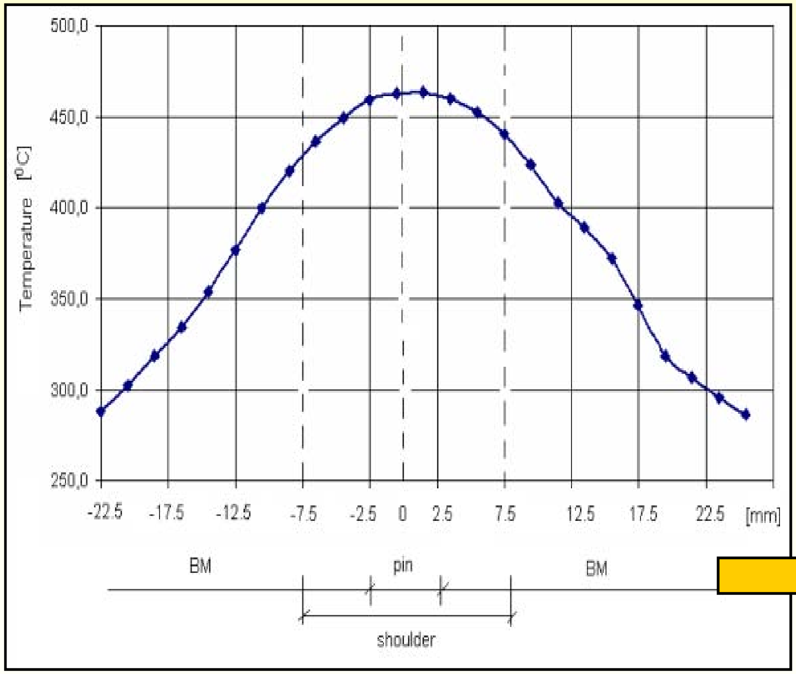


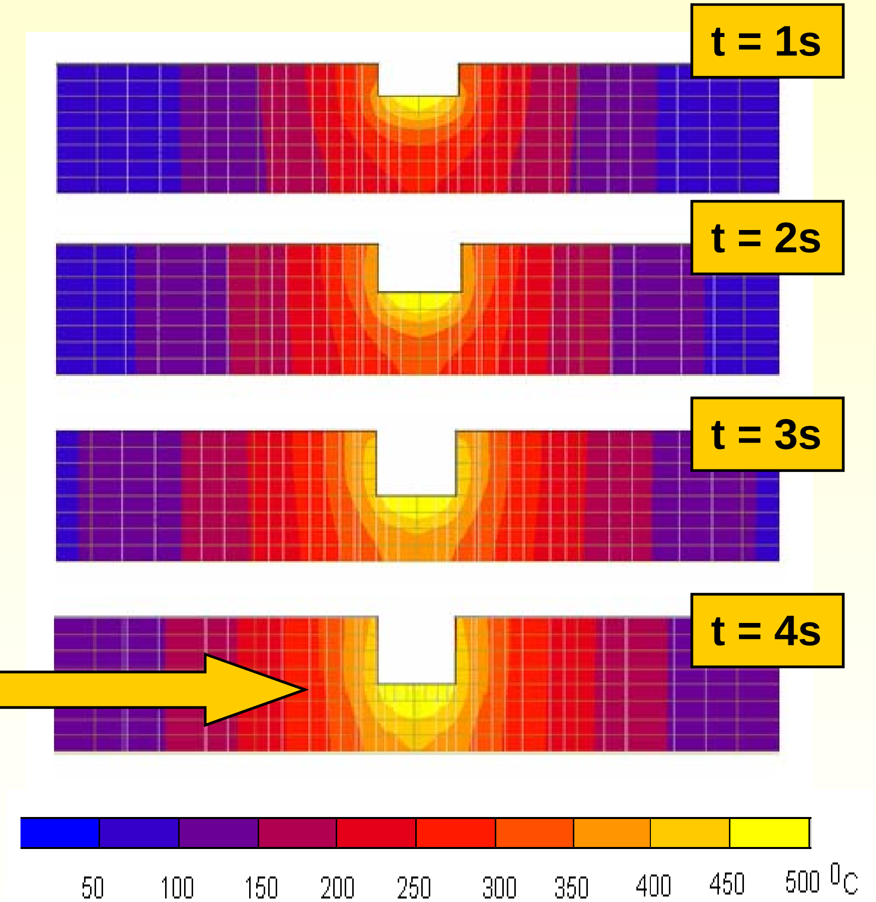
Retreat time 2.5 s

The tool is considered a rigid solid, and the workpiece is considered a ductile material characterized with elasticity, plasticity, and a kinetic hardening effect.

3. FEM model – several results

Temperature

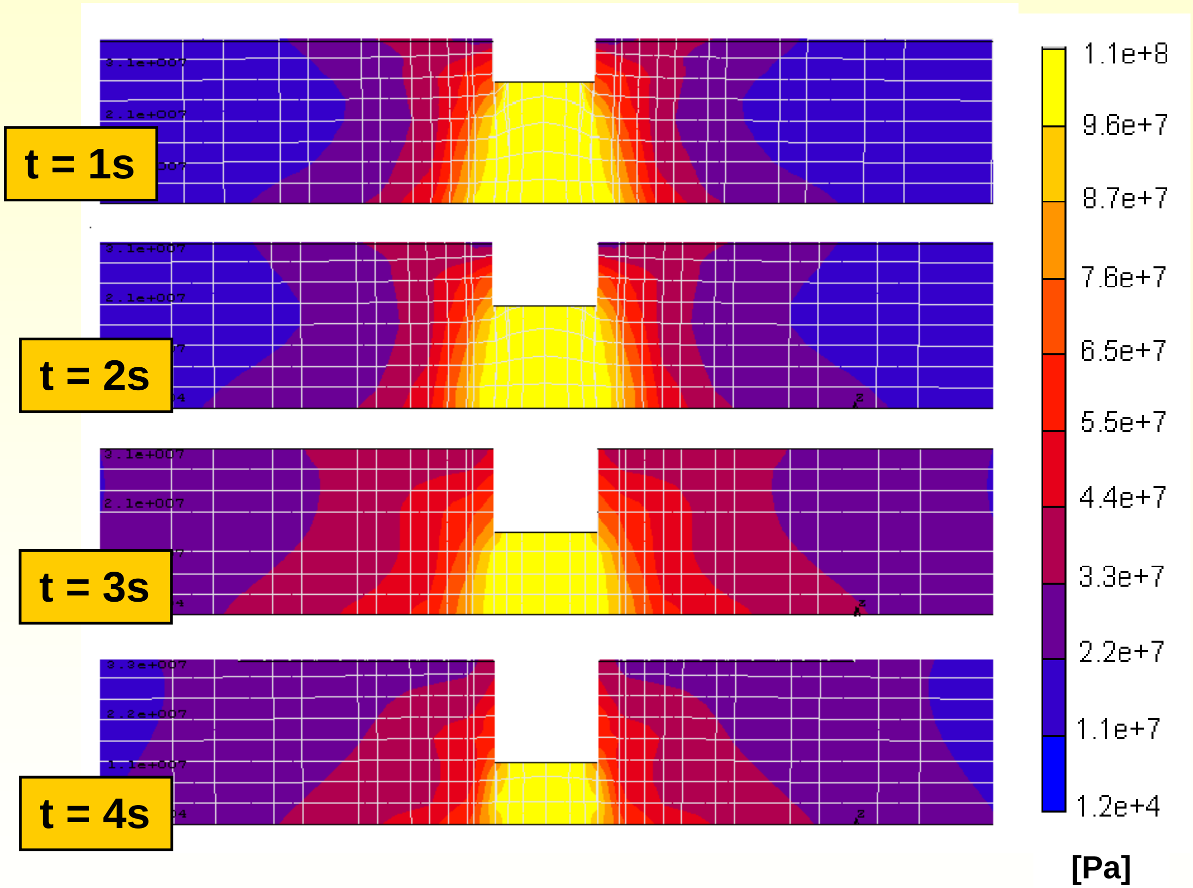




Temperature contours in the cross-section perpendicular to the weld.

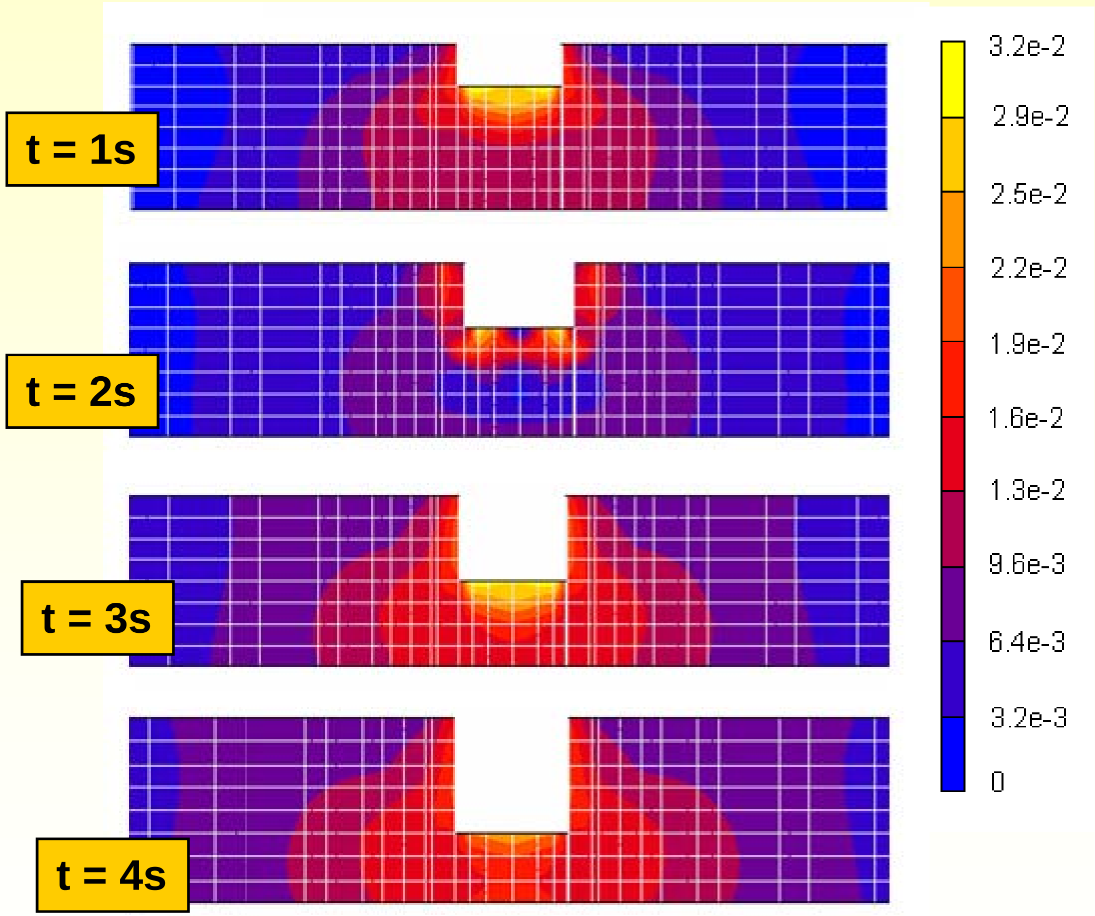
3. FEM model – several results

Von Mises equivalent stress



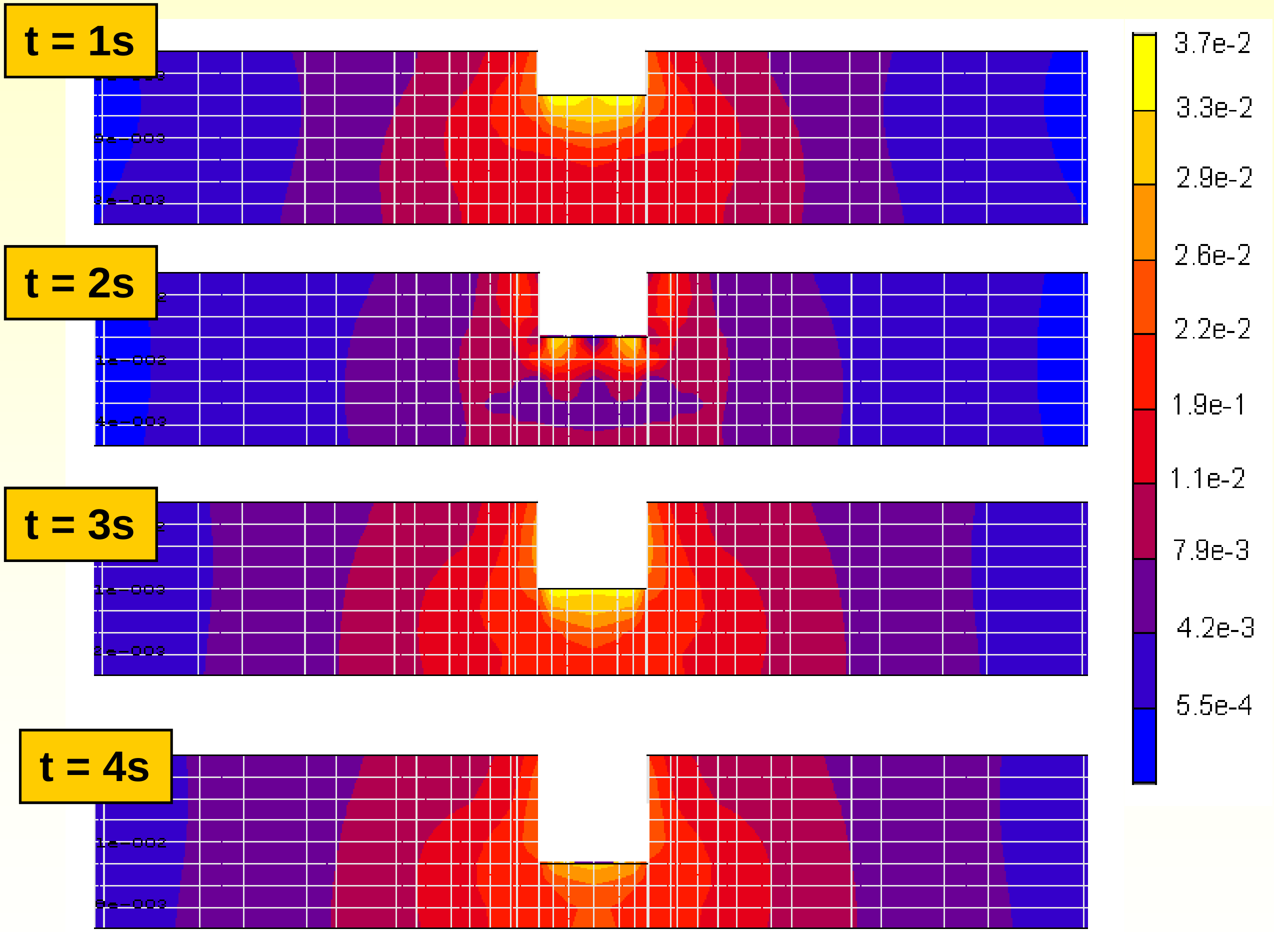
3. FEM model – several results

Plastic strain



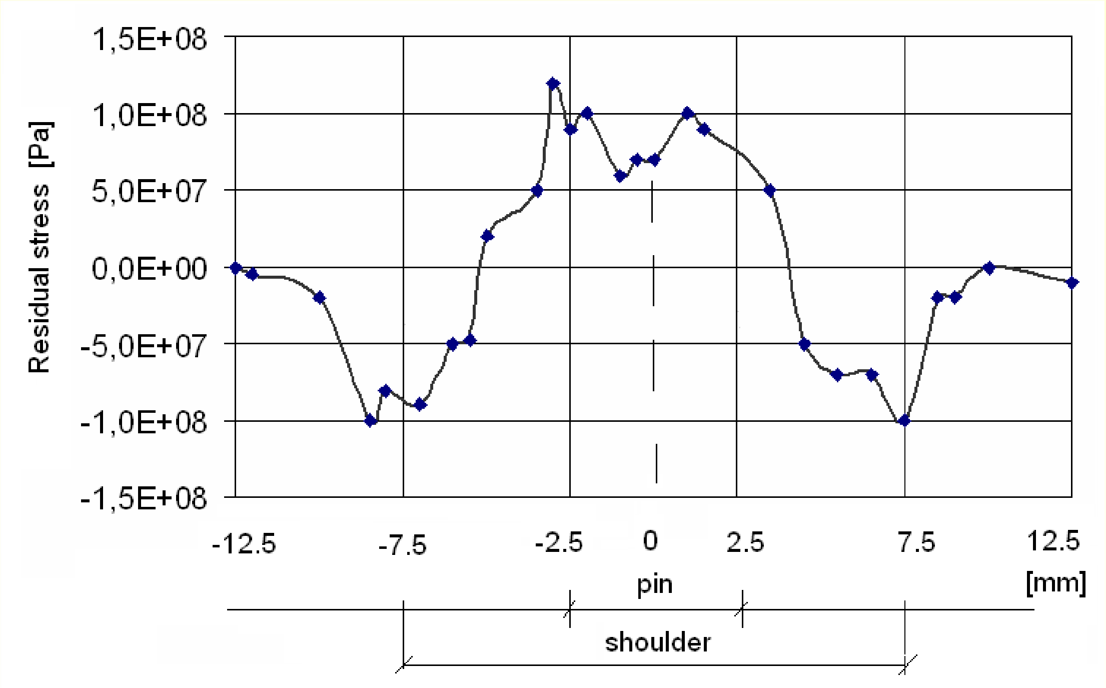
3. FEM model – several results

Total strain



3. FEM model – several results

Residual stress

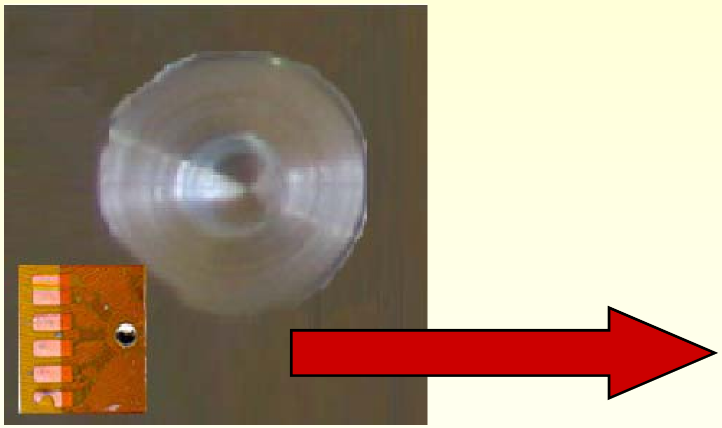


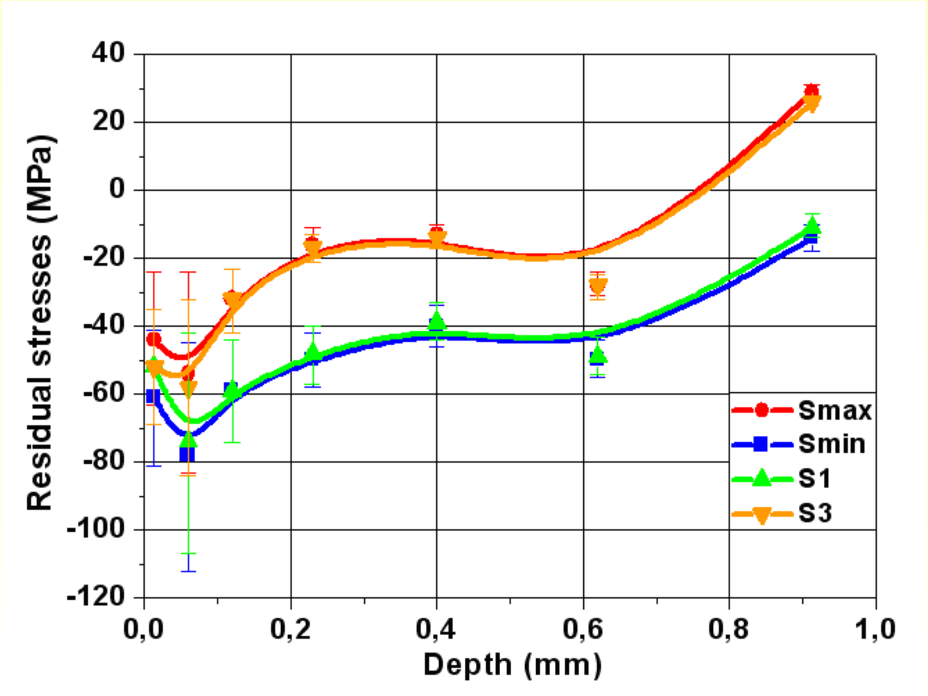
FEM

The predicted stress distribution shape complies with literature on FSW of different Al alloys

4. Validating the model

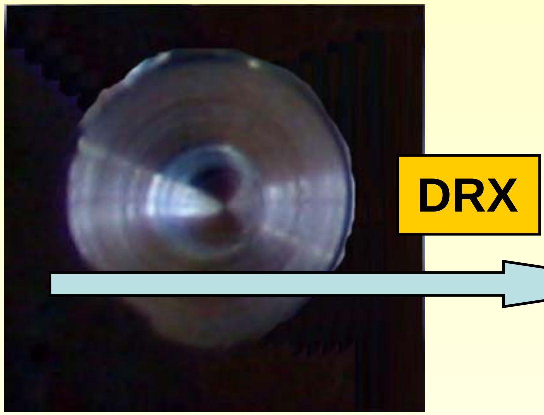
The X-ray diffraction (XRD) and drilling hole technique were used to measure the residual stresses



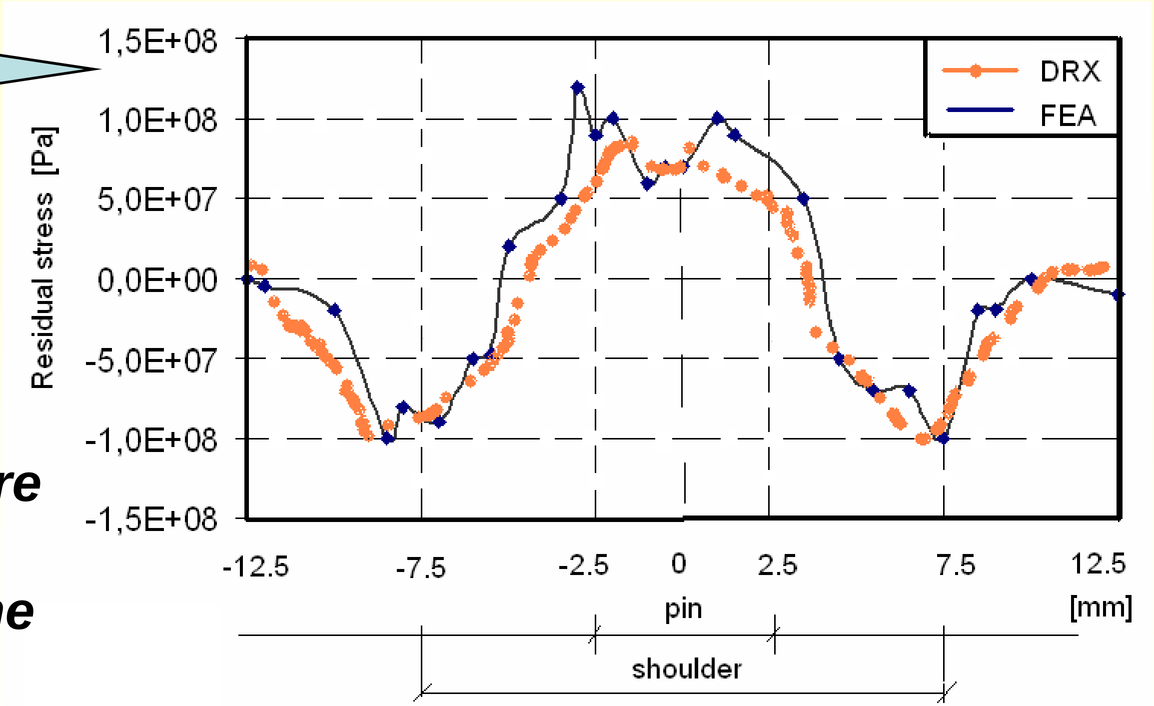


Drilling hole on 1mm depth in HAZ

4. Validating the model



X-Ray Diffraction



The measurements were performed on a Ψ – diffractometer using the sin2ψ –method

Note: featured method was use because of Aluminium

5. Conclusion and outlook

1. Necessary outputs were provided by the model: *thermal field, stress-strain field, hardness field, microstructural description*
2. The *numerical results matches* previous results from *literature* or/and *experiments*
3. *Various* and *flexible methods* for *validating* the predicted *hardening* and *hardness field* may be used
4. *Various complementary experimental methods* must be used to validating *residual stress/strain field prediction*
5. The presented example *optimizes the criterion time / results*, and opens wider further approaches and prospects

5. Conclusion and outlook

1. Experiments on *multilayer FSSW*
2. Modelling and experiments on *dissimilar FSSW*
3. *Coupling* the results with more comprehensive and accurate *structural assessment codes*
4. Developing models for *other FSW methods, variants and variances* by using this start up
5. *Optimising* the *validation procedures* and emphasising the *effectiveness* of the *direct* and/or *inverse engineering methods* to obtain good rate time/results

Thank you very much!